SHORT NOTES

HERPETOLOGICAL JOURNAL, Vol. 15, pp. 291-294 (2005)

AN EXAMINATION OF *PIPA PARVA* (ANURA: PIPIDAE) FROM NATIVE AND INVASIVE POPULATIONS IN VENEZUELA

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Invasive populations of anurans contribute to global amphibian declines, and many instances involve pipid frogs. Here we report on an invasive population of *Pipa parva* in Carabobo State, and a native population in Zulia State, Venezuela. The frogs were found in high densities in a fish farm near Lake Valencia, and had a diet of benthic invertebrates. Invasive *P. parva* were large compared to those described in previous reports (mean snout-vent length: 37.34±0.73 mm), but the native population was found to be significantly longer (mean snout-vent length: 44.08±1.34 mm). Colonisation by terrestrial movement and potential impact of this invasive species are discussed.

Key words: diet, invasive amphibians, morphology, South America

While much recent attention has focussed on amphibian declines (Houlahan *et al.*, 2000), the incidents of problematic introduced amphibians continue to rise (Kats & Ferrer, 2003). Thorough investigations of some invasive anurans have exemplified a wide range of mechanisms of impact, including: competition, disease, toxicity and predation (e.g. Cunningham & Langton, 1997; Kupferberg, 1997; Lafferty & Page, 1997; Crossland, 2000). Results suggest a positive relationship between density and impact, and in some studies, that high densities are a significant factor in concerns over global amphibian decline.

The family Pipidae has five extant genera of principally aquatic anurans, four (*Hymenochirus, Pseudhymenochirus*, *Silurana* and *Xenopus* in sub-Saharan Africa and one (*Pipa*) in central and South America. The best known invasive pipid is *Xenopus laevis*, and its detrimental effects have been documented in California, UK and Chile. For example, an endangered fish (*Eucyclogobius newberryi*) was found in the gut contents of *Xenopus laevis* inhabiting the estuary of the Santa Clara River, California (Lafferty & Page, 1997), and in both UK and Chile *X. laevis* probably con-

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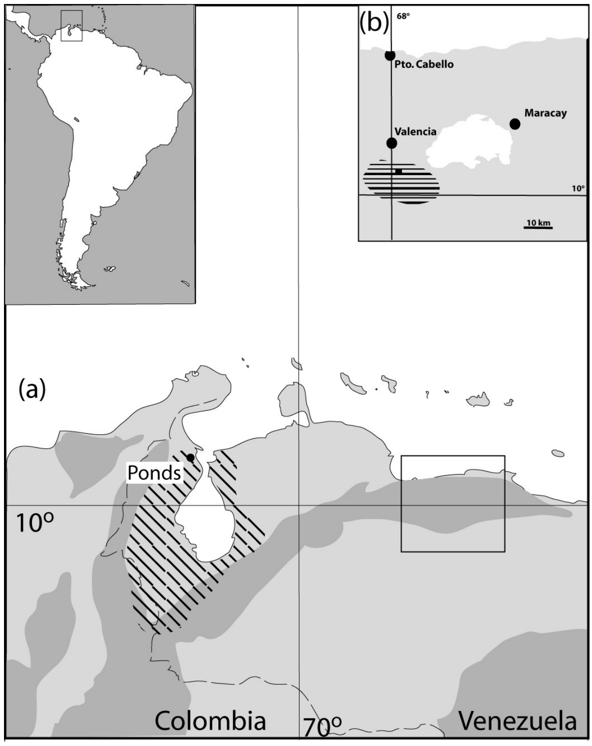

FIG. 1. Known distribution of *Pipa parva* in Venezuela and Colombia (right sloping lines) with the extension of the Cordillera Oriental shown as shaded areas (a) The range is approximated with data from Trueb & Cannatella (1986), Gines (1958) and Barrio & Fuentes (2000). (b) The introducted range (horizontal lines) is approximated from the area, south of Valencia, where fish farmers have reported *P. parva* (personal communication to RR). The location of Ventuari fish farm is shown with a black square.

sumes local amphibian eggs and larvae, as well as causing trophic cascades by consumption of benthic macroinvertebrates (Measey, 1998*a*; Lobos & Measey, 2002).

The genus *Pipa is* represented by four species in Venezuela (Gines, 1958): *Pipa aspera*, *P. parva*, *P. Pipa* and P. *arrabali*. *Pipa parva* is endemic to the Lake Maracaibo region (Zulia and Tachira States) in the north east of Venezuela (Trueb & Cannatella, 1986). Lake Maracaibo lies in the north-west corner of Venezuela bordering Colombia, and *P. parva is* restricted in its distribution by mountains to the west (Perija Range) and east (Cordillera de Merida), both extensions of the Cordillera Oriental, which dominates the region (Fig. 1). Royero & Hernandez (1996) reported the presence of *Pipa parva*, outside of its native Lake Maracaibo drainage, in the western area of Lake Valencia, Venezuela (Fig. 1). The movement of *P. parva* to Carabobo State is attributed to anthropogenic means, with the intention of breeding individuals for the national and international market in ornamental aquarium livestock.

Here we examine an invasive population of *Pipa parva*, collected from a fish farm in the Valencia area (Carabobo State), and compare them to a sample of animals from the native Maracaibo drainage (450 km

TABLE 1. Stomach contents of 42 *Pipa parva* from an invasive population caught at the Ventuari fish farm, near Valencia, and five *P. parva* caught in a pond from a native population near Maracaibo, Venezuela.

	Total frequency	% occurence	Average frequency	Total mass	Average mass	Mass / frequency
Ventuari Fish Farm, Valencia						
Chironomid larvae	899	93	21.4	1.057	0.025	0.001
Ephemeropteran larvae	31	33	0.7	0.109	0.003	0.004
Coleopteran larvae	34	33	0.8	0.147	0.004	0.004
Ostrocod (long)	64	21	1.5	0.017	0.000	0.000
Ostrocod (small)	46	24	1.1	0.009	0.000	0.000
Snail eggs	1	2	1.3	0.044	0.001	0.044
Maracaibo, Venezuela						
Planorbid snails	7	40	3.5	0.3851	0.077	0.55

west in Zulia State). Particular attention is paid to one of the chief attributes of an invasive species: individual impact (Parker *et al.*, 1999) through the examination of diet.

Ventuari fish farm lies 8 km south of Valencia on the Valencia-Las Lomas road, Carabobo State (10° 06' N; 68° 08' W. Altitude 520 m asl; Fig. lb). The farm has 20 outdoor holding ponds (approx. 10 × 50 m and 1 m depth), nine of which are within an anti-bird mesh enclosure, and all ponds are bounded by a 0.5 m anti-crocodile wall. *Pipa parva* were collected using unbaited funnel traps with 50 mm diameter openings. Traps were regularly left submerged in each pond throughout the day and emptied in the evenings when most of the catch would normally have drowned (E. Garcia, pers. comm.). Pools were occasionally drained and sun dried as a means of reducing the numbers of *P. parva*, as well as liming with calcium hydroxide to reduce the risk of disease, parasites and fungal infections to farmed fish.

On the 3 April 1997, the live contents of traps from six meshed holding ponds were pooled in a glass

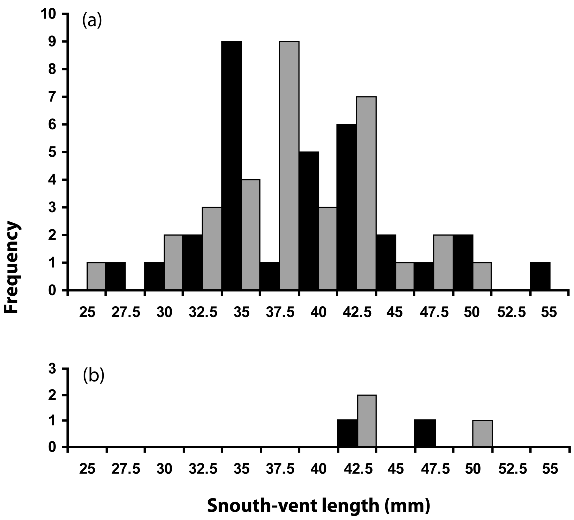

FIG. 2. Frequency distibution histograms for snout-vent length of *Pipa parva* caught (a) from an invasive population in Ventuari fish farm, south of Valencia, and (b) in a native population north of Maracaibo, Venezuela. Black bars are females and grey shaded bars males.

aquarium tank overnight. The following day, the contents of the same traps were removed live at 1500 hr. Water temperature was 28.0° C and the mud substrate 27.4° C. The pH of the water was 10.54; this elevated level presumably due to liming.

Ponds and irrigation ditches were sampled, using seine and pond nets, along the highway to Dami Tulé, Zulia State (10° 43' N; 71° 43' W. Altitude 15 m asl; Fig. 1a), and within the native range of *Pipa parva*. *P. parva* were only found in one small pond (approx. 5 × 6 m and 1.5 m depth), which was repeatedly seined. Temperature and pH of the water were noted as 32.9° C and 9.37 respectively.

After collection, specimens of *Pipa parva* were lethally anaesthetised with MS222 (Sandoz) and preserved with 10% formalin, which was also injected into the body cavity. Specimens are to be deposited into the collection of Natural History Museum, London (BMNH). Snout-vent length (SVL) measurements were made using dial callipers to the nearest 0.1 mm. Stomach contents were removed and identified using a binocular dissecting microscope. Sex was determined from direct examination of gonads during dissections. A two-way ANOVA (Statistica v. 5.5A, StatSoft, France) was used on log (ln) normalised SVL data to test for differences between sexes and populations.

A total of 64 *Pipa parva* were collected and preserved for use in this study. Five animals (three males, two females) were obtained using seine nets from the pond near Lake Maracaibo (Fig. 2b). More animals were seen to escape the seine net as it was retrieved, indicating that this was not the total population of the pond. The six traps collected at the fish farm yielded 42 *P. parva* on 3 April, 1997, with an extra 17 animals captured the previous night (total of 59: 30 males, 29 females; Fig. 2a). All 64 animals were used in the morphological analysis, but the 17 animals kept overnight were not included in the analysis of diet.

Female *P. parva* from the fish farm were found to be slightly longer (mean±SD = 37.91±1.18 mm) than males (mean±SD= 36.77 ±0.86 mm), although this difference was not significant (two-way ANOVA: $F_{1,60}$ = 0.029; P=0.865; Fig. 2). Despite the small sample size, the native population had larger mean SVL for females (mean±SD = 44.0±2.00 mm) and males (mean±SD = 44.13±2.15 mm), and these animals were found to be significantly larger than specimens from the fish farm (two-way ANOVA: $F_{1,60}$ = 6.32; *P*=0.015; Fig. 2). The interaction between sex and site was not significant (two-way ANOVA: $F_{1,60}$ = 0.038; *P*=0.846).

Table 1 shows the composition of stomach contents of animals captured at the fish farm, all with items of benthic origin. Most individuals (93%) had ingested chironomid larvae, which made up the major component of stomach contents in both frequency and mass. Other items also included aquatic insect larvae (Ephemeroptera and Coleoptera), as well as two species of ostracods. One individual had ingested snail eggs. Only two stomachs had contents from animals captured near Maracaibo, both of these contained aquatic snails (Table 1).

Despite the small sample size, *Pipa parva* from the natural population in Maracaibo were found to have a significantly greater SVL than the invasive population from the fish farm in Valencia. Trueb & Cannatella (1986) report that SVL of museum specimens of *P. parva* they studied are smaller than those found here: means for females are given as 33.6±1.2 mm (female SVL range 27.0-44.3 mm; *n*=19), and for males as 31.7 ±0.5 mm (male SVL range 27.9-37.0 mm; *n*=21). Trueb & Massemin (2001) report on the sizes of a small sample of *Pipa aspera* which had a significant size dimorphism between sexes (two tailed *t*-test on data from their Table 1), but no significant sexual size dimorphism was found for *P. parva* despite the larger sample size.

Trueb & Massemin (2001) claim that *P. parva* is the smallest of the 'micropipas', but we show here that different populations can have different mean sizes. Fig. 2a shows larger maximum sizes for both females (SVL 55.0 mm) and males (SVL 46.1 mm), both from the Ventuari fish farm. That animals from the Maracaibo population were significantly larger suggests that SVL ranges may be even greater than those reported here. Trueb & Cannatella (1986:438) also report that the 'venter of the body and limbs is grayish tan, and either immaculate or bearing a few, small, indistinct spots in the pectoral region of some individuals.' We found that all animals collected (both from Maracaibo and Ventuari fish farm) had lightly spotted venters, which did not fade in preservation.

Our results suggest that *P. parva* is a generalist predator of appropriately sized aquatic fauna. Gines (1958) describes the diet of Venezuelan frogs of the genus *Pipa* as consisting of larval insects as well as small fish and tadpoles. Similar prey was reported to be taken by captive *P. aspera,* including tadpoles of *Hyla boans* and minute characid fish (Trueb & Massemin, 2001). *Pipa arrabali* was found to exert strong predatory pressure and influence the distribution of *Osteocephalus taurinus* eggs and tadpoles (Gascon, 1992). Buchacher (1993) found that *P. arrabali* were quick to devour tadpoles of *Phyllomedusa bicolor* which dropped into a pond from a foam nest. He also observed that *P. arrabali* left their ponds to prey upon larvae of *Leptodactylus knudseni i*n terrestrial foam nests. Another pipid, *Xenopus laevis* was also found to take many items of terrestrial origin, presumed to have fallen into the surface film, but also being snatched from around the water body (Measey, 1998*a*). However, for ingestion it is necessary for *X. laevis* to return to the water (Measey, 1998*b*), and this appears not to be the case for *Pipa* (see Buchacher, 1993). Another notable difference between the diets of frogs from these two genera is the absence of planktonic prey items reported from the diet of *Pipa*. This may simply reflect the abundance of available bethic prey, although Measey (1998*a*) showed that most *X. laevis* still took planktonic prey whilst benthic prey was not only available, but abundant.

Royero & Hernandez (1996) speculated on an economic impact by *P. parva* on fish farmers. While our results do not find that these frogs prey on either fish or fish fry, our sampling was not exhaustive, and the extent of predation and/or competition with farmed fish lies open to further investigation. That *P. parva* are predators of farmed fish and fish fry, or that they are in competition with farmed fish by eating fish food, as claimed by Royero & Hernandez (1996), seems likely. Outside of the fish farms, it is probable that *P. parva* are also predators of other native Venezuelan anuran eggs and larvae, as well as fish. Most reports of the effects of invasive amphibians have an emphasis on native amphibian fauna and highlight direct predation on amphibians by adult invaders, although this is likely to be an artefact of the types of studies conducted. Few studies have considered predation pressure on native invertebrate fauna. However, assessments of total impact (area occupied, abundance, and impact per individual sensu Parker *et al.,* 1999) are absent from the literature, and yet desperately needed.

The fish farmers of Valencia claimed that during the onset of big rains, the farms are invaded by thousands of *Pipa parva*, and this requires the frogs to climb over the 0.5 m anti-crocodile walls surrounding the farm. In addition, Royero & Hernandez (1996) stated that fifteen days after constructing new pools at a fish farm near Valencia, these were found to contain a large number of *P. parva* larvae which were thought to compete with fish for food.

Pipids are often thought of as completely aquatic frogs which rarely venture out of the water. Péfaur & Cardoso (1992) made notes on *Pipa carvalhoi* and *P. parva* walking and jumping out of water. Péfaur observed *P. parva* jump in a very cumbersome manner, reaching a height of 0.7 m but moving horizontally only half of this distance (Péfaur & Cardoso, 1992). This ability to move overland may explain the rapid invasive process over a large portion of the Valencia area. Interestingly, it appears that *Pipa carvalhoi* also occurs in invasive populations in Rio State, Brazil (E. Dubauskas, pers. comm.).

Venezuela has legislation designed to protect against invasive species (resolution No. 260 of the Ministry of the Environment and Renewable Natural Resources), although Royero & Hernandez (1996) comment that there are not sufficient resources to tackle such problems. Urgent studies are needed in order to assess the natural and economic impact of *Pipa parva* in the vacinity of Valancia. Special efforts should be made outside of the fish farms to determine whether these frogs have entered into the Lake Valancia drainage system. Within fish farms, evidence is needed of predation or competition by both adults and larvae, as claimed by fish farmers, and a quantification of economic impact per individual. The use of unbaited funnel traps within fish ponds provides a practical and inexpensive manor of trapping unwanted *Pipa parva.* This method could be augmented by occasionally baiting the traps, as described by Measey & Tinsley (1998). In order to reduce invasions by *P. parva* moving overland, drift fencing and pit fall traps could be constructed behind the anti-crocodile wall. The enforcement of existing Venezuelan legislation is pivotal in reducing growing problems of invasive species.

Acknowledgements. We thank Tito Barros, Mark Wilkinson and Peter Miller for help with collections of animals in Maracaibo and Valencia, respectively. We extend our thanks to E. Garcia and Ventuari fish farm who aided and facilitated this study. This work was made possible by NERC grant NERC GR9/02881 to Mark Wilkinson, Natural History Museum, London, and we are indebted to him for making this study possible.

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Accepted: 19.10.04